Enclosure 2

GDP 98-0286

USEC-01

Application for United States

Nuclear Regulatory Commission Certification

Paducah Gaseous Diffusion Plant, Revision 34

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APPLICATION FOR UNITED STATES
NUCLEAR REGULATORY COMMISSION CERTIFICATION
PADUCAH GASEOUS DIFFUSION PLANT
REMOVAL/INSERTION INSTRUCTIONS
REVISION 34
DECEMBER 23, 1998

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3.4 UF_6 PRODUCT WITHDRAWAL FACILITY

The product withdrawal systems for PGDP are housed in C-310 and C-310-A which is attached to and located immediately north of C-310. The facilities in these buildings provide two complete withdrawal systems that permit simultaneous withdrawal of two product streams with different ^{235}U concentrations. One system is identified as the top product withdrawal system, while the other system is designated the side product withdrawal system. Either system can be used to withdraw material of any assay up to the plant limit of 2.75 wt % ^{235}U. When the C-315 Tails Withdrawal Facility is unavailable, tails withdrawal may be performed at C-310.

Normetex pumps in C-310 compress the UF_6, the liquefaction and accumulation is performed in C-310-A, and the cylinder filling operation is conducted in C-310. Each facility has local operating controls and the ACR in C-310 provides additional instrumentation. Fine control of the assay level of the product being withdrawn is accomplished by monitoring of the withdrawal stream with mass spectrometers and/or by analyzing gas stream samples periodically collected during cylinder filling operations.

3.4.1 Description

UF_6 from the diffusion cascade is compressed to a pressure of approximately 30 psia and then cooled to approximately 160°F to condense it. The liquefied UF_6 flows by gravity into 2½- or 10-ton (or 14-ton for tails only material) cylinders. Each cylinder being filled is mounted on a scale that monitors the cylinder weight. When the predetermined cylinder weight limit is almost reached, an audible alarm on the scale is sounded to alert the operator, and the valve in the UF_6 drain line to the cylinder automatically closes. The filled cylinder is disconnected and moved outside the building for cooling and solidification of the UF_6 product. Noncondensible contaminant gases remaining in the cylinder are removed by connecting the cylinder to the "burp" station at C-310 and evacuating it for several hours. Gases evacuated from the cylinder are either (1) routed back to the cascade or (2) passed through sodium fluoride traps to remove any UF_6 before discharging the remaining gases to the atmosphere through the C-310 stack.

The components associated with the product withdrawal systems, except product cylinders, are fabricated of corrosion-resistant materials, such as nickel alloys, nickel-plated steel, copper, or aluminum. Most joints in the withdrawal systems are welded.

3.4.2 Normetex Pumps

Two Normetex pumps are installed on the C-310 cell floor at the north end of cell 9 and cell 10. Both pumps are 350 cfm units, which were developed and manufactured in France. The pump at cell 10 was installed as a test unit in 1981 and was tested on air, light gases, and UF_6 prior to installing the unit at cell 9.

The Normetex pump uses a fixed and a moving spiral vane. The moving vane has an eccentric motion causing "pockets" between the vanes to open and close to compress the gas and move it from the inlet to the discharge of the pump (see Figure 3.4-1). This design permits compression of UF_6 without the use of dynamic seals between the process and atmosphere. The moving vane is powered by two electric motors. The pump uses three crankshafts. Two are connected to the motors and one is an idler. All are supported by precision bearings.

A spacer column connects the fixed vane to the pump body, and the moving vane is attached to the base of the spacer column by two concentric metal bellows that separate the UF_6 from atmosphere and serve as an inlet to the pump. The space between the two bellows is buffered and monitored by instrumentation designed to detect a leak from either bellows.

The UF_6 enters the pump through fine mesh inlet gas filters designed to prevent any foreign material entry that might increase the wear of the vanes. An inlet control valve regulates the amount of flow through the pump by controlling the suction pressure at approximately 1 psia to 6 psia during normal operation. The pump discharge is then routed to one of the three UF_6 condensers at a pressure of approximately 30 psia. The discharge pressure could be considerably higher than the normal operating pressure under a blocked discharge line condition. A buffered expansion joint rated at 45 psia internal pressure and 55 psia in the buffer area is installed between the pump and the block valve on the outlet line. Dual pressure transmitters read the discharge pressure and actuate the pump shutdown circuit at approximately 42 psia. A 37 psia discharge pressure warning alarm and 39 psia pump shutdown are also included to avoid pumping conditions that might overload the pump motors or potentially damage the pump if allowed to persist. These two latter settings are not associated with the AQ-NCS trip at or below 42 psia, although they share some common components and the same ultimate action (pump shutdown).

The pump is lubricated and cooled by oil, which is pumped through sealed passages in the spacer column and the vanes. The oil is returned to the 80-gallon, self-contained oil reservoir by gravity flow through and around the shaft bearing surfaces. An oil heater and oil cooler are used as necessary to maintain the desired oil temperature between 149°F to 185°F. The upper temperature limit prevents expansion of the vanes, while the lower temperature prevents formation of solid or liquid UF_6. Either of these problems could cause rubbing and subsequent damage to the pump.

A simplified schematic for the product and tails withdrawal facility showing the location of the Normetex pumps is shown in Figure 3.4-2.

In addition to normal instrumentation and controls, the C-310 Normetex pumps include one system required to be included in the TSR (see Figures 3.4-3 and 3.4-4).

- UF_6 leak detection system consists of Pyr-A-Larm heads, which are mounted in close proximity to the pump housing and discharge lines. The process control system monitors these heads. This system will alarm when any head fires (sounds a "trouble" alarm) and will shut the pump down and close the outlet block valve if any two adjacent heads are actuated. The pump cannot be restarted until the UF_6 detection system is reset. Additionally, the process control systems fire the detectors every 6 hours to help maintain detector sensitivity. The detector heads can also be fired manually.

The following additional instrumentation is included here for better understanding of the system design by the reader. These instruments are not identified as TSR systems:

- Watt-meters and thermal overloads on both drive motors with an alarm and shutdown on high power or current. Attached oil pump with a thermal overload and alarm.
- Oil system and inlet UF_6 gas differential temperature indication. If the inlet gas temperature significantly exceeds the oil system temperature, the oil system may not be able to remove the heat of compression, which could cause thermal expansion of the pump vanes leading to pump damage.
- Temperature indication on the UF_6 suction and discharge lines.
- Flow control with the inlet control valve which fails closed and closes upon pump shutdown.
- Outlet block valve, which closes upon pump shutdown.
- Pump shutdown upon outlet block valve closure. An override feature must be manually engaged to allow the pump to be started with the valve closed prior to being placed on-stream.
- Pump inlet UF_6 gas high suction pressure trip at approximately 7-psia, which prevents pump overload.
- Buffered expansion joints on the inlet and outlet lines.
- Alarms and pump trips associated with oil system problems (e.g., low oil flow, low oil pressure, low oil level, and high oil temperature).
- Pump discharge UF_6 gas high pressure trip at or below 42 psia (this prevents condensation of HF in the condensers for nuclear criticality safety purposes in C-310 only).

3.4.3 Uranium Hexafluoride Condensers

The product withdrawal system uses three UF_6 condensers. Each condenser is approximately 12½-ft long and 11 in. in diameter with a pressure rating of 400 psig on the shell side and 75 psig on the tube side. The shell is manufactured with ASTM A-106 steel and the "U"-type tubes in the tube bundle are manufactured from monel to resist corrosion.

Thickness measurements are taken on the withdrawal area UF_6 condensers at least every five years in order to establish corrosion rates, determine estimated remaining life and verify the vessel wall has not been reduced below minimum required metal thicknesses per the current version of the National Boiler Inspection Code.

UF_6 enters the tube side of the condenser at approximately 30 psia, where it is cooled and condensed to a liquid by R-114 coolant passing through the shell side. The R-114 is cooled with RCW in a coolant condenser similar to the process building coolant condensers.

Not all the gaseous material supplied to the condenser is liquefied. A portion of the UF_6 flow and that part of the noncondensible gases not entrapped in the liquid UF_6 are returned to the cascade via the condenser vent. These gases are normally returned near the stage of the cascade from which they are withdrawn. However, they may be returned to other portions of the cascade (at a suitable assay match point) or vented to surge drums in one of the other buildings. A vent control valve regulates the condensing pressure and the flow of gases back to the cascade. The condenser pressure is controlled and measured in the C-310 control room. The No. 1 and No. 2 condensers are part of the product condensing system, and the No. 3 condenser is part of the side withdrawal system, although it may be used for product, side or tails withdrawal.

3.4.4 Uranium Hexafluoride Liquid Accumulators

Two UF_6 liquid accumulators serve the withdrawal system. The product accumulator is a 21,000-lb capacity nickel-lined tank used in the top product system. The side accumulator is monel-lined steel with a 4,300-lb capacity. The accumulators located on the second floor below the condensers provide surge volume by "floating" on the drain line. A vent line with a control valve is provided to permit the return of noncondensibles to the cascade and to control pressure.

Thickness measurements are taken on the withdrawal area UF_6 accumulators at least every five years in order to establish corrosion rates, determine estimated remaining life and verify the vessel wall has not been reduced below minimum required metal thicknesses per the current version of the National Boiler Inspection Code.

3.4.5 Cylinder Filling Stations

There are two cylinder filling stations or withdrawal positions in normal use in C-310. Each has a cylinder cradle arrangement mounted on a cart, which is moved on a floor track system. A cylinder to be filled is placed in the cradle and the cart is moved into position on a scale at the filling station. A removable pipe or "pigtail" connects the filling station to the cylinder valve. The pigtails used for product withdrawal are similar to those used in the feed facilities. However, withdrawal pigtails are exposed to ambient conditions and are thus susceptible to freeze-out (UF_6 solidifying in the pigtail due to a temperature decrease). For this reason, withdrawal pigtails are wrapped with electrical heat tracing covered with insulating tape to reduce the likelihood of freeze-out. Each cylinder filling station has an exhaust hood connected to a common exhaust duct, HEPA filter, and fan, which is then exhausted to atmosphere. This prevents the accumulation of any residual gases that might arise from withdrawal operations.

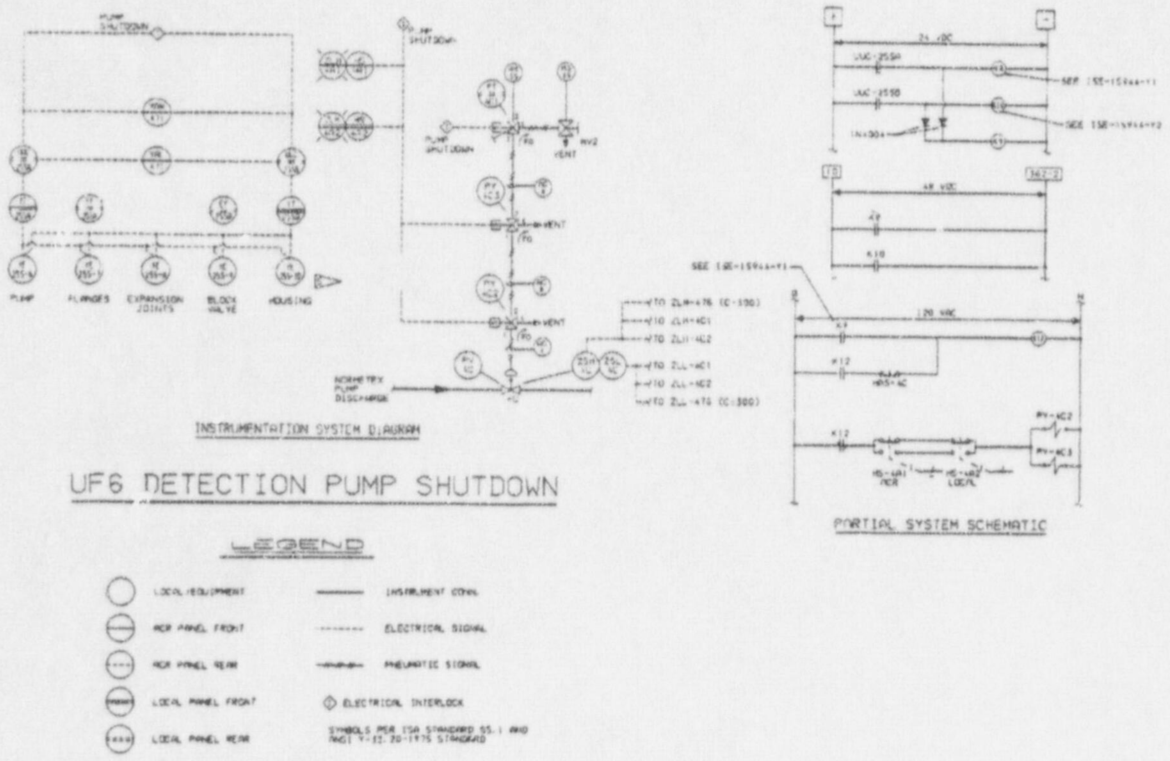

Figure 3.4-3. West Normetex pump instrumentation.

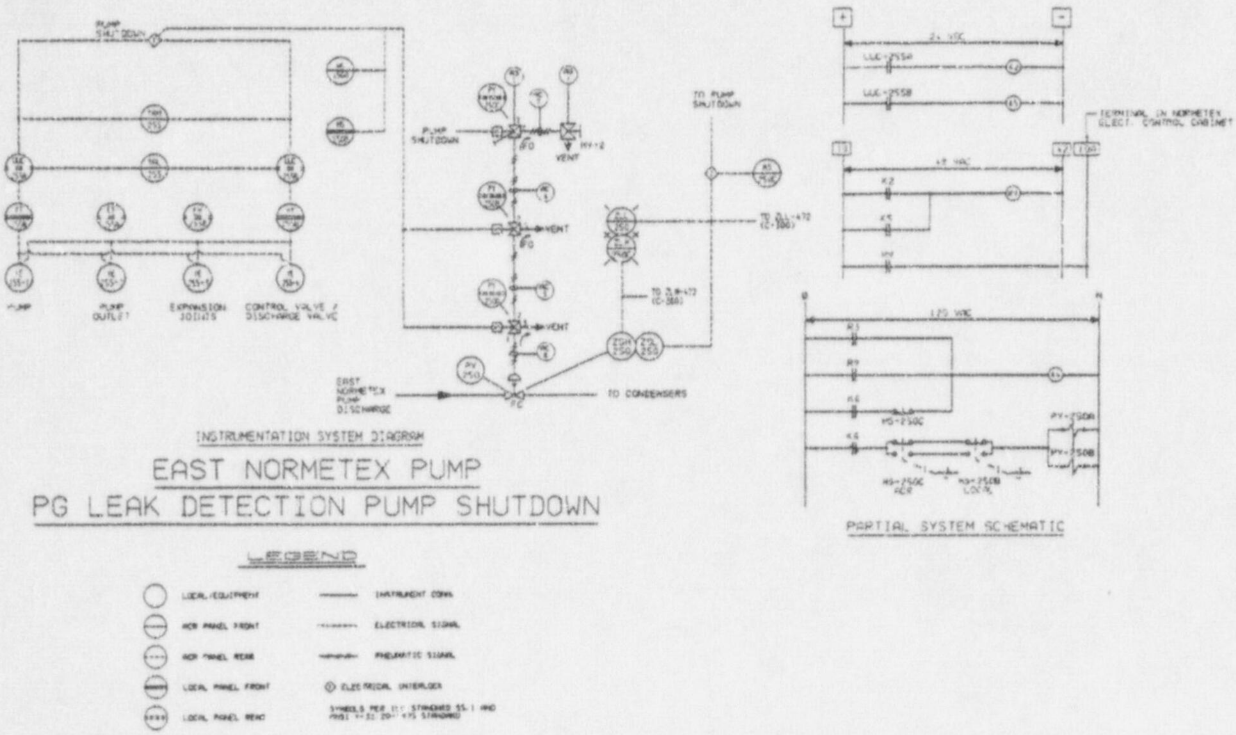

Figure 3.4-4. East Normetex pump instrumentation.

3.5 UF_6 TAILS WITHDRAWAL FACILITY

Withdrawal of UF_6 tails from the enrichment cascade is accomplished with a compression and liquefaction system quite similar to that used for product withdrawal. The tails withdrawal facility is housed in the center portion of C-315. A temporary storage yard for tails cylinders, located east of the tails withdrawal facility, is served by a semi-gantry crane.

3.5.1 Description

The two primary purposes of the C-315 building is to provide a cascade surge volume consisting of two 20,000 ft^3 Hortonspheres (normally, one on-stream and one off-stream) and to compress and condense the tails UF_6 to permit withdrawal through the withdrawal system (see Figure 3.5-1). The surge volume of the Hortonspheres helps control cascade inventory fluctuations.

These two functions are accomplished by routing the "B"-stream from the bottom of the cascade in the C-331 building (via one or both of two low-speed compressors) to the on-stream Hortonsphere as well as using the suction of the Normetex pumps or high-speed compressors. At lower withdrawal rates, a low-speed compressor may not be required. One or more of the three Normetex pumps operate in parallel and discharge to the UF_6 condensing system. Two high speed compressors in C-315 that are maintained in standby can be used in lieu of the Normetex pumps. The flow through the Normetex pumps is normally controlled by the pressure in the on-stream Hortonsphere. The process gas is returned from the on-stream Hortonsphere via a control valve to the bottom of the cascade in C-331 building as the "A"-stream. Since the on-stream Hortonsphere floats on the discharge of the low-speed compressors, it provides a surge volume for changes in tails withdrawal as well as flows to and from the cascade.

Expansion joints, valve stems, and compressor shaft seals are equipped with special sealing and buffering systems to prevent leakage.

The UF_6 from either the Normetex pumps or high-speed compressors is piped at approximately 30 psia to a condenser, where the gas is condensed by cooling to a temperature of about 160°F. The liquid UF_6 flows by gravity into a 10- or 14-ton tails storage cylinder at one of the four cylinder filling positions. During filling, the cylinders rest on cradles on rail-mounted carts positioned on scales at each station. The scales provide a weight readout and an adjustable audible alarm to alert the operator when that limit has almost been reached. A valve in the UF_6 drain line then automatically closes to prevent overfilling of the cylinder. Before moving a cylinder from the filling station, an accountability weight is established so that, in the event of an overfill, evacuation of the excess UF_6 can be performed with the cylinder in the drain position. After a cylinder has been filled with tails material, it is carefully transported outside by the use of the air-operated scale cart. It is then lifted by a double-block 20-ton crane and carefully transported to the temporary storage area for tails cylinders where it remains until its contents have cooled and solidified (5-day cooldown period). Only then is the cylinder moved to a long-term storage yard.

3.5.2 Compression Components

3.5.2.1 Normetex Pumps

Normetex pumps are used to compress the UF_6 withdrawal stream from the on-stream Hortonsphere for liquefaction. Three Normetex pumps are installed on the second floor of C-315. The three pumps are 350 cfm units developed and manufactured in France. The Normetex pumps are operated with one or more running in parallel, taking a suction from the header supplied by the low-speed compressors and discharging to one or more UF_6 condensers, which are also operated in parallel. Additionally, the No. 3 Normetex has an alternate suction and discharge valves that enable compression from a separate source. This could allow tails withdrawal at a second assay value. However, a second assay is not normally withdrawn in C-315. This alternate piping allows the pump to be used as an evacuation pump for operations such as evacuating the off-stream Hortonsphere. Refer to Section 3.4.2 for a description of the Normetex pumps, including the UF_6 Leak Detection Shutdown system (a TSR system).

A location and piping plan for the Normetex pumps is shown in Figure 3.5-1.

1. Gamma detector channel
2. Cluster logic module
3. Cluster housing
4. Associated circuitry
5. Local electric horn
6. Backup battery for the cluster and horn
7. Connecting cable to connect to the building system

3.15.1.3.8 Text Deleted

3.15.1.3.9 Product and Tails Withdrawal Area 20-ton Overhead Bridge Cranes

Q Function

The cranes (one each in C-310 and C-315) function to safely move liquid-filled cylinders from the scale cart to the storage area.

See Section 3.4.8.2 and 3.5.8.2 for a description of this system.

Boundary

The system boundary includes:

1. Crane structure and structural supports, the crane rails, the bridge, the mechanical rail stops at the end of the bridge, the trolley rails, the trolley, and the reeving.

2. D.C. rectified shoe brakes

3. Relays for hoist brake control

4. Hoist motor contacts

5. Geared up/down limit switch

6. Two paddle-type limit switches

7. Emergency stop button

8. Proximity switches

9. Associated circuitry

The crane brake fails safe on loss of power.

3.15.1.3.10 UF_6 Cylinder Lifting Fixtures

Q Function

Liquid UF_6 cylinder lifting fixtures are built and maintained to prevent the dropping of a cylinder, resulting in a possible release.

See Sections 3.4.8.2 and 3.5.8.2 for a description of this system.

Boundary

The system boundary includes:

1. Wire rope legs

2. Lifting fixture assembly.

3.15.1.3.11 Scale Carts

Q Function

The function is to safely move cylinders containing liquid UF_6.

See Sections 3.4.8.1 and 3.5.8.1 for a description of this system.

Boundary

The system boundary include

1. Cradles and substructure system.

3.15.1.3.12 C-310/C-315 Condenser, Accumulator and Liquid UF_6 Process Piping and Valves

Q Function

The UF_6 condensers and accumulators (C-310 and C-315) and associated piping and valves were designed to safely contain liquid UF_6 and to provide the means to withdraw UF_6 from the cascade.

See Sections 3.4.3, 3.4.4, 3.5.4, and 3.5.5 for a description of this system.

Boundary

The Liquid UF_6 Process Piping and Valves system boundaries include:

1. Condenser

2. Accumulator vessels

3. Piping/valves containing liquid UF_6 from the condenser through the withdrawal manifold.

4. Piping/valves containing high-pressure gaseous UF_6 downstream of the Normetex pumps/hi-speed centrifugal compressors

3.15.1.3.13 UF_6 Cylinders

Q Function

Cylinders utilized to contain UF_6 have been designed, built and tested to ANSI N14.1 and a prescribed minimum volume specified in USEC-651. This ensures safe containment of UF_6 during transport, sampling, feeding, filling, and storage and to prevent a release of liquid UF_6. The issue of fail safe is not applicable to this system.

The 2S and 1-kg cylinders are not included as Q due to their small size. These cylinders are classified as AQ.

See Section 3.7.1 for a description of this system.

Boundary

The system boundary includes:

1. Cylinder

2. Cylinder valve

3. Cylinder plug.

The valve protector has been identified as AQ.

3.15.1.3.14 UF_6 Pigtails

Q Function

UF_6 cylinder pigtails are designed to safely transfer liquid UF_6 from the enrichment process to a cylinder during withdrawal operations.

See Sections 3.4.5 and 3.5.6. for a description of this system.

Boundary

The system boundary includes:

1. Pigtail assembly, including the tubing, adapter, and gaskets.

3.15.1.4 UF_6 Sampling and Transfer Facility

Q systems for the C-360 Toll Transfer and Sampling Facility are listed.

3.15.1.4.1 Autoclave Water Inventory Control System

Q Function

The system function is to isolate the sources of condensate upon detecting a high condensate drain line water level in order to prevent over-pressurization of the autoclave or the possibility of a criticality upon a UF_6 release.

See Section 3.6.7.3 for a description of this system.

Boundary

The system boundary includes:

1. Condensate level probes:
2. Steam supply block valves
3. Thermovent block valve
4. Air supply
5. Solenoid valves and piping to the block valves

3.15.2.12 Cascade Piping and Equipment

AQ Function

Provides UF_6 containment (pressure boundary) during the enrichment process.

See Section 3.3.1.2 and 3.3.4.5 for a description of this system.

Boundary

Cascade piping and equipment includes UF_6 process gas piping 2 in. and larger, expansion joints, valves, and process equipment containing UF_6.

System Boundaries

1. From the second autoclave isolation valve to the exit point from buildings C-333A, C-337A
2. From C-360 second autoclave isolation valve up to and including evacuation drums (which can be evacuated to C-337)
3. From entry point into building to exit points in buildings C-331, C-333, C-335, C-337
4. From entry point of building to and including the Normetex pumps/hi-speed centrifugal compressors in buildings C-310 and C-315
5. UF_6 tie lines: all buildings from entry/exit point to next building entry/exit point

Only the characteristics of the listed equipment which provide the UF_6 containment function are controlled as AQ SSCs. Internal parts (e.g., compressor blades, valve gates, barrier, etc.) that do not form part of the UF_6 pressure boundary are not AQ.

3.15.2.13 Non-radiological Chemical Systems

AQ Function

The non-radiological chemical systems provide containment of non-radiological chemicals identified as part of the chemical safety program in Section 5.6.

See Sections 5.6.13.2, 5.6.13.3, 3.8.3, 3.8.4, and 3.4.9.

Boundary

Chlorine System

1. For C-611-B, C-611-S, and C-615, the vacuum regulator and chlorine leak detectors and associated alarms.

2. For C-631, C-633, C-635, and C-637 all piping components including the flexible connection, pipe, valves up to and including the vacuum regulator and the chlorine leak detectors and associated alarms.

ClF_3 System

1. The distribution piping from the chlorine trifluoride storage tank including the flexible connection, pipe and valves

2. The instrumentation that controls the tank pressures to less than atmospheric pressure

3. The chlorine trifluoride leak detectors and associated alarms

F_2 System

1. The fluorine storage tanks and distribution piping including the flexible connection, pipe, valves, and relief devices

2. Fluorine leak detectors and associated alarms.

3.15.2.14 Cell Remote Manual Shutdown System

AQ Function

The cell remote manual shutdown system manually shuts down the cell operation in case of emergencies.

See Sections 3.3.7.2.1, and 3.3.7.2.3 for a description of this system.

Boundary

The system includes:

1. Manual shutdown button or switch in the Area Control Room (ACR), at the Local Cell Panel (LCP), and on the cell floor

2. Red Air Circuit Breaker (ACB) indicating lights in the ACR and at the LCP

3. HAA auxiliary relays at the process substations

4. ACB trip coil and auxiliary contacts, the 250 volt DC breakers, battery and charger

5. "00" ACB housing switch

6. 51X-2 "00" auxiliary relay

7. 15 kV ACB air tank and pressure switch in "000"

and is monitored to detect any leaks. A pressure change of ± 0.75 psi between the bellows would cause automatic pump shutdown and alarm. Consequently, no release of UF_6 is expected from a fatigue failure in a concentric bellows.

If a failure were to occur on the discharge bellows or outlet piping, UF_6 would be released into the C-310 building cell floor area. The discharge bellows could fail from fatigue or overpressurization. If the pump discharge valve were to fail closed on an on-stream pump, the discharge pressure would rise rapidly and could conceivably rupture the pump discharge bellows. Assuming a failure of the discharge bellows or piping, and a withdrawal rate of 70,000 lb/day, 50 lb of UF_6/min would be released on the C-310 cell floor. This release could continue until the pump is automatically shut down by the UF_6 detection safety system. A conservative source term for this low probability accident would be 250 lb of UF_6 released. A more realistic source term would be 100 lb of UF_6 released over a 2 minute period due to the close proximity of UF_6 detectors to the pump. The alarming of any two adjacent detectors will actuate the pump trip circuit and shut down and isolate the pump. This release is further mitigated in that it would occur on the cell floor of C-310. The building would provide holdup of reactants and would slow the release to the environment.

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4.3.3.1.2 Condenser and Accumulator Failures

The UF_6 accumulators and condensers are built in accordance with the ASME Boiler and Pressure Vessel (B&PV) Code, Section VIII. They are inspected at five-year intervals in accordance with the current edition of the National Board of Inspection Code (NBIC). Tests have shown there has been no appreciable loss of metal from either the C-310 or C-315 accumulators. A fatigue failure of components located between the Normetex pump and the product condensers would result in the release of UF_6 as described in 4.3.3.1.1. A failure between the condenser and the drain station block valves would result in a release from the liquid UF_6 portion of the system.

The rupture of a withdrawal system component containing liquid UF_6 could result from a fatigue failure of an instrument line on the accumulator or the fatigue failure of the drain line from the accumulator. The worst case in either of these low probability accidents would occur if the accumulator was partially filled during the change out of UF_6 drain cylinders at the withdrawal station.

The instrument line break is characterized by a leak from a severed ¼ in. diameter copper tube. In this instance, the UF_6 is estimated to leak out of the system at a rate of 133 lb/min. A leak on the drain line could be larger depending on the location and type of break, but in no case would the total leak be greater than 1,000 lb of UF_6.

The high voltage UF_6 detection system located in this area will alarm in the C-310 ACR and in C-300, but does not initiate automatic actions. It is assumed that this system would alarm in approximately 15 sec and alert the C-310 ACR operator to a possible release. The ACR operator would don full protective equipment, physically verify the release, notify C-300, and return to the ACR to perform valving operations to isolate the leak and reduce the system pressure by evacuation. These actions could require up to 40 minutes to accomplish. If the release is small, the lengthy response would not increase the total release above the 1,000 lb estimate. If the release approaches 133 lb/min, the release will be readily apparent from outside the facility, and the ACR operator would initiate mitigative steps. These operations are estimated to require no more than 5 minutes to complete from the start of the release until the system is evacuated.

The UF_6 detection system is a safety system; however, the valves, controls, etc., used in the isolation and evacuation of the condensers and accumulators are not identified as safety system components due to the varied and diverse means available for system evacuation. If the UF_6 condenser vent valves and the accumulator vent valve fail to open, the system can be evacuated through the pump evacuation valves or the evacuation valves at the withdrawal stations. These actions may take longer than 5 minutes to accomplish if personnel protective equipment must be donned to access these areas.

4.3.3.1.3 Valve and Pigtail Failure

The worst-case accident scenario considered possible at the product withdrawal station is a complete rupture of the drain manifold to cylinder pigtail with the accumulators partially full. This could result from an inadvertent scale cart movement while the pigtail is attached. In analyzing this scenario, it is assumed the cylinders receiving the liquid UF_6 are always filled with the valve in the 12 o'clock position.

The testing and inspection of pigtails before UF_6 service reduce the likelihood of this accident. A key-operated interlock switch shuts off the air supply to the cart, and administrative controls require the key ring to be placed on the pigtail when it is connected to a cylinder. In addition, a pressure sensor on the drain line prevents cart movement unless the pigtail is at atmospheric pressure, (±3 psi). However, should the pigtail become completely severed and dislocated, UF_6 would escape from the manifold end of the severed pigtail at a rate of 20 lb/sec and from the cylinder end at a rate of 80 lb/min.

The withdrawal areas at PGDP are equipped with a UF_6 release detection and isolation system which includes two, fast-acting block valves on each drain manifold and a valve closer on each cylinder valve as described in SAR section 3.4.7. Assuming a 5 sec response time for the UF_6 detection unit, a 1 sec closure time for the manifold block valves, and 10 sec for the cylinder valve closer to operate, the total outleakage from this medium probability accident is 140 lb of UF_6. Although testing at C-360 tends to support these closure times, the valve specifications accept longer times. This scenario will be reevaluated in the ongoing GDP Safety Analysis Report (SAR) Upgrade Program.

The evaluation presented above is the existing safety basis analysis for a valve or pigtail failure at the production withdrawal station. However, the assumed release detection and valve actuation times may not be conservative. The release has been recalculated based on more conservative values for detection time (15 sec), block valve closure time (15 sec), and cylinder valve closure time (30 sec). Using the same release rates assumed above (20 lb/sec liquid release from the manifold end of the break and 80 lb/min gaseous from the cylinder end), the total release would be 660 lb of UF_6. This higher value reflects an upper bound for this potential release and has been used in the TSR basis statement.

4.3.3.1.4 Buffered Valve and Flange Failures

The consequences of failure of buffered valves or buffered flanges are difficult to evaluate because of the failure mechanisms involved. These systems are designed primarily to protect against releases resulting from metal fatigue type failures in the thin metals used in these applications. Valve bellows will occasionally fail, but the outleakage rates will vary with the degree of damage. Buffer systems are monitored so that leaks are readily detected and can be isolated.

The potential accidents and releases described above have negligible safety consequences. Any small amounts of hazardous material which might escape into the facility from a heated enclosure containing these expansion joints and valves would be readily detected by both sight and odor before they reached hazardous proportion. That would enable operating personnel to evacuate the immediate area and notify the ACR operator to isolate the leak and activate emergency response personnel. Because of this low risk situation, these buffer systems are not considered to be safety systems.

Before a critical configuration can exist in any of the pits, a well moderated uranium solution would have to accumulate to a depth of at least 5 in. Thus, the criticality accident of concern for pits in C-360 is from an accumulation of uranium and moderator, most likely in the form of water, in one of the pits. For such a scenario to occur, a large release of UF_6 would have to happen and that uranium would have to reach the pits. Second, sufficient moderator would have to be present in the pit. In order for the water to be in the pit, the sprinkler system would have to release water or the water would have to already be there in the pit when the uranium arrived.

Uranium could enter the pits through a release of UF_6 in an autoclave, through a handling incident in or around the scales or elevator, or by a chronic accumulation of uranium from many small releases such as those which can occur during pigtail disconnection. An automated water sensor and alarm system is in place in the elevator pit to detect the presence of a water accumulation prior to achieving a depth of 5 in. If water is detected in the pit, an audible alarm is actuated and immediate action is taken to remove the accumulated water. A quarterly inspection of all the pits and drains is performed to verify that no uranium deposits are accumulating and to verify that the pit drains and elevator pit sump pump are operational.

Two oil interceptors are in C-360 so that all of the floor drain lines to the storm sewer must pass through them. During a UF_6 release, it could be possible to introduce uranium into these interceptors which could contain moderator in the form of oil and water. For this reason, valves in the effluent lines automatically close when a release is detected in the building. This would prevent a significant amount of uranium from entering the oil interceptors. Should these valves fail to close, hundreds of pounds of uranium would have to mix homogeneously with the oil or water in the interceptors before it approached criticality.

4.4.3.4 Product Cylinders

The product cylinders used at PGDP to store UF_6 vary in size. Under the right conditions it is possible to have a criticality resulting from a rupture of a large cylinder and/or from the addition of moderating material to a cylinder containing enriched uranium. Three situations are postulated that could result a critical configuration:

1. withdrawal of a moderator in the form of HF along with UF_6 into a cylinder during the filling process which could result in a criticality by exceeding the acceptable H/U ratio;

2. in the event of a leak or rupture of a large cylinder, the addition of a large amount of water into the cylinder which reacts with the contents and results in a critical configuration;

3. rupture of a cylinder which releases uranium compounds to atmosphere, and that material precipitates out of the atmosphere by rain or water spray and accumulates in solution in an unfavorable geometry outside the cylinder.

Double contingency cannot be demonstrated for large UF_6 cylinders since moderation is the only control to ensure subcriticality. The amount of enriched uranium necessary for a critical configuration depends on geometry, composition, and the introduction of moderator (water). The exact geometry of a mixture of UO_2F_2 and water resulting from a UF_6 release from a ruptured cylinder or from introducing moderator into a cylinder containing enriched material is nearly impossible to predict due to the complex nature of the chemical reactions and many other variables. (Situations 2 and 3 above.)

The most likely moderating material to be encountered in a cylinder is HF that is fed to the withdrawal cylinder through the cascade. Using moderation as the primary nuclear criticality safety control for product cylinders is based on the ability of the gaseous diffusion plants to produce high purity UF_6 ($\geq$ 99.5% pure). This purity corresponds to an H/U ratio of approximately 0.088. Assuming the remaining 0.5% impurity was composed entirely of HF, it would not provide sufficient moderation of the neutrons to sustain a nuclear chain reaction. The UF_6 condensers are maintained under strict temperature and pressure controls to ensure the amount of HF is low enough to meet the required H/U ratio, and consequently, the UF_6 purity specification. Double contingency is demonstrated for the control of the HF concentration.

Once filled with UF_6, necessary controls are implemented to ensure that the integrity of the cylinders is maintained. Specifically, administrative controls are in place to (1) visually inspect for cylinder damage or corrosion, (2) space cylinders containing liquid UF_6 to minimize the possibility of cylinder damage during handling, and (3) restrict cylinder handling such that cylinders containing liquid UF_6 are not lifted over other cylinders nor stacked and that cylinders are not lifted over liquid cylinders.

4.4.3.5 Accumulators

The two UF_6 accumulators which serve the product withdrawal system are located in C-310A. The product accumulators are large and resemble a 10-ton product cylinder. The side withdrawal accumulator, also in C-310A, is smaller and has a capacity of 4300 lb. The accumulators provide a surge volume for the UF_6 withdrawal process.

Moderation control, as described above for the product cylinders, is the primary barrier to criticality in the accumulators. Uranium enriched to 6 wt % ^{235}U or less cannot achieve criticality unless moderation is present. Since UF_6 readily reacts with moisture to form UO_2F_2 and HF, it is necessary to keep the cascade free of moisture. Therefore, the entire system design is meant to preclude introduction of moisture into the cascade. The only mechanisms for moisture to enter the system are for the moisture to come through the product withdrawal pumps from the cascade, for the system to leak (wet air inleakage), or for purge gas (N_2 or air) laden with moisture to be misdirected into the UF_6 product header.

Moisture in the cascade would react with the UF_6 gas before it reached the Normetex pumps and would have formed HF gas. The HF gas released in the cascade would pass through to the product condensers and be vented, or be passed to the cylinder, where it would later be purged in the burping of the cylinder. The temperature and pressure in the withdrawal system are maintained to keep the HF concentration low enough that the H/U ratio in the system is low. Since the product withdrawal system is kept at pressures well above atmospheric pressure, any breach of the system integrity would cause the UF_6 present to be released to the atmosphere, rather than allowing air to leak into the system.

4.4.3.6 C-310 Scale Pits

The scale pits in the C-310 product withdrawal system are approximately 8 ft wide by 12 ft long and are located beneath each drain station. Before a critical configuration can exist in the scale pits, a uranium solution would have to accumulate to a depth of at least 5 in. This represents a significant quantity of uranium and moderator.

Table 4.9-1. PGDP accident scenario summary table. (Continued)

Number/Initiating Event	Section	Worst Case Accident	Prob. per Year	At Subatmospheric Operation			At Full Power Operation		
				Maximum Source Term	Hazard Level	Risk	Maximum Source Term	Hazard Level	Risk
23. UF6 Hydrocarbon oil reaction in UF_6 cylinder	4.3.3.5	Release inside UF_6 handling facility	Extremely Low (A)*	28,000 lbs UF_6	Medium (4)	Extremely Low	28,000 lbs UF_6	Medium (4)	Extremely Low
24. Liquid cylinder drop/impact	4.3.4.1.5	Release outside UF_6 handling facility	Low (B)	28,000 lbs UF_6	Medium (4)	Low	28,000 lbs UF_6	Medium (4)	Low
25. Fatigue/break of pigtail	4.3.3.1.3	Release inside UF_6 handling facility	Medium (C)	140 lbs UF_6	Extremely Low (2)	Low	140 lbs UF_6	Extremely Low (2)	Low
26. UF cylinder valve failure	4.3.3.2	Release inside/outside UF_6 handling facility	Low (B)	720 lbs UF_6	Extremely Low (2)	Extremely Low	720 lbs UF_6	Extremely Low (2)	Extremely Low
27. Text deleted									
28. Failure on discharge of Normetex pump	4.3.3.1.1	Release inside UF_6 handling facility	Low (B)	250 lbs UF_6	Extremely Low (2)	Extremely Low	250 lbs UF_6	Extremely Low (2)	Extremely Low
29. C-315 compressor failure from thermal reaction	4.3.4.1.1	Release inside UF_6 handling facility	Low (B)	50 lbs UF_6	Extremely Low (2)	Extremely Low	50 lbs UF_6	Extremely Low (2)	Extremely Low
30. C-315 compressor seal failure	4.3.4.1.1	Release inside UF_6 handling facility	Medium (C)	5-10 lbs UF_6	Extremely Low (2)	Low	5-10 lbs UF_6	Extremely Low (2)	Low
31. Fatigue failure of accumulator instrument line	4.3.3.1.2	Release inside UF_6 handling facility	Low (B)	1,000 lbs UF_6	Extremely Low (2)	Extremely Low	1,000 lbs UF_6	Extremely Low (2)	Extremely Low

Table 4.9-1. PGDP accident scenario summary table. (Continued)

Number/Initiating Event	Section	Worst Case Accident	Prob. per Year	At Subatmospheric Operation			At Full Power Operation		
				Maximum Source Term	Hazard Level	Risk	Maximum Source Term	Hazard Level	Risk
32. Fatigue failure of accumulator drain line	4.3.3.1.2	Release inside UF_6 handling facility	Low (B)	1,000 lbs UF_6	Extremely Low (2)	Extremely Low	1,000 lbs UF_6	Extremely Low (2)	Extremely Low
33. Uranium solution in non-geometric configuration	4.4.5	Criticality	Extremely Low (A)	10^{17} Fissions	Medium (4)	Extremely Low	10^{17} Fissions	Medium (4)	Extremely Low

* This probability includes current operations but does not include recycle of existing tails cylinders (see Section 4.3.1.5).

pump discharge pressure is maintained by regulating the condenser vent valve to maintain the proper condensing temperature and pressure.

The product withdrawal system uses three UF_6 condensers. The UF_6 condenser consists of a tube bundle enclosed in a cylindrical-shaped container approximately 12.5 feet long and 11 inches in diameter. UF_6 enters the condenser tube bundle where it is cooled and condensed to a liquid by R-114 coolant passing over the bundle. The R-114 is in turn cooled with RCW in a coolant condenser similar to the process building coolant condensers. Not all of the gaseous material supplied to the condenser is liquefied. A portion of the UF_6 flow and that part of the noncondensible gases not entrapped in the liquid UF_6 are normally returned to the cascade via the cell below the product withdrawal cell. A control valve regulates the condensing pressure and the flow of gases back to the cascade. The condenser pressure is controlled and measured in the C-310 control room. The No. 1 and No. 2 condensers are part of the product condensing system and No. 3 condenser is part of the side withdrawal system.

Two accumulators serve the withdrawal system by storing liquid UF_6, if required. One of the accumulators (Top Withdrawal System) is a tank with a 21,000-lb capacity. The other accumulator (Side Withdrawal System) is a tank with a capacity of 4300 lb. The accumulators are located on the second floor below the condensers and provide surge volume by "floating" on the drain line. A vent line with a control valve is provided to permit the return of noncondensibles to the cascade and to control pressure.

There are two cylinder filling stations in normal use in Building C-310. Each station has a cylinder cradle arrangement mounted on a cart which is moved on a floor track system. A cylinder to be filled is placed in the cradle and the cart is moved into position on a scale. The scale is located in a large pit at the filling station. The scale cart is a low profile design with a skirt with sloped sides to inhibit inadvertent admission of UF_6 and its reaction products into the scale pit. The scale pit covers are designed to divert liquids away from the pit. While liquid UF_6 is being drained into the cylinder, the weight of the material transferred can be read from the scale to determine when the cylinder fill limit has been reached. Before the cylinder weight limit is reached, an alarm on the scale set at slightly below the cylinder fill limit sounds to alert the operator. A valve in the UF_6 drain line is then automatically closed to prevent overfilling of the cylinder. The cylinder fill manifold is then purged, evacuated, and disconnected. The cylinder is then moved to the cylinder yard for cooling. Normal convection cooling is sometimes supplemented with water spraying.

After the liquid UF_6 product has cooled and has solidified, the cylinder can be connected to a manifold at the C-310 burp station. This manifold contains two exhaust lines. One exhaust line is for cylinder pigtail purge gases, which are exhausted to the cascade purge system in Building C-310; the other line is to a NaF trapping system which absorbs any UF_6 that might be pulled from the cylinder. The cylinder pressure is evacuated with an ejector to a pressure of less than 10 psia by exhausting noncondensibles such as R-114 or inert purge gases. The evacuated gases are discharged through NaF chemical traps. For more details on trap operation, see Sect. 2.6.2.7.

The original product and side withdrawal operation used Twelliott pumps and associated equipment. This entire system is not in use anymore and is isolated, cut, and capped from the withdrawal equipment currently in use. The Twelliott system cannot be put back into service without NCS approval.

Instrumentation. An on-line assay spectrometer normally provides continuous monitoring of the assay level of the product. A very small amount of UF_6 is sampled at the same point of product withdrawal as a continuous sampling operation. This sample becomes the official sample on which the assay of the contents of the filled cylinder is based.

Physical changes to the NaF traps and associated instrumentation are discussed in Sect. 2.6.2.7. The only other physical changes in this area of operation were to the burp stations described above. This change reduced the dike height to 3.5 inches to maintain a favorable geometry for collection of accidental spills. Some controls are required to address the potential enrichment of assays greater than 2 wt % ^{235}U. For additional information on Product Withdrawal Operations, see Sect. 3.4 of the SAR.

The criticality safety is based on the information in *NCSE of the Normetex Pumps Used for UF_6 Withdrawal at PGDP*, KY/E-144[21], and *NCSE for Product Withdrawal in the C-310 Building at PGDP*, 3974-05.[22]

System analysis

It was determined from the analysis in Sect. 4 that the only significant hazard due to HAUP during product withdrawal operations is criticality.

The criticality concerns for the product withdrawal process are primarily moderation control and maintaining system integrity.

Detailed analysis of the Normetex pump used for product withdrawal was performed in the Normetex Pump NCSA[21] with the results requiring strict controls on pump configuration. Credit was taken in the analysis for the high discharge pressure system to preclude excessive pressures in the system. The high discharge pressure system also controls moderation in the withdrawal process (see Fig. 2.6-8). During the withdrawal process, the limits on the H/U ratio in the product cylinders will be maintained to less than or equal to 0.088 as indicated in USEC-651[23]. This applies to all types of cylinders in addition to all assay levels. Further detail on use and handling of cylinders during withdrawal operations is included in Sect. 2.6.2.6.

System integrity for the entire process is of utmost importance to prevent a release of UF_6 for direct exposure concerns and the potential for criticality. Existing systems are used to protect system integrity in this area of operation. Specific analyses of the product withdrawal processes are available in the NCSAs for C-310 Operations[22] and the Cylinder Burp Station[24].

Safety features and controls

As required, design features for safety, administrative controls, and surveillances were developed to support operation at enrichments up to 5.5 wt % ^{235}U. These safety features are listed below.

Design features for safety. The scale carts are designed to have a low profile with a skirt with sloped sides to inhibit inadvertent admission of UF_6 and its reaction products into the scale pit. The scale pit covers designed to divert liquids away from the pit.

Administrative controls. The Product Withdrawal Facility and equipment contained therein shall not be operated at assays greater than 2.75 wt % ^{235}U.

2.6.2.5.2 Cylinder handling

Cylinder handling for all areas of product withdrawal operation is addressed in Sect. 2.6.2.6.

2.6.2.6 UF_6 Cylinder Handling

2.6.2.6.1 Standard UF_6 cylinders

System description

The cylinders normally used for transport and storage of UF_6 feed, product, and tails materials are the 48-inch-diameter 10- and 14-ton heavy and 14-ton thin-wall cylinders, and the 30-inch-diameter 2.5-ton cylinders. Current cylinder data and handling guidelines are in accordance with USEC-651[23]. At present the Nuclear Regulatory Commission (NRC) and the Department of Transportation (DOT) regulate transport of these

In addition to the NCS surveillances the operating organizations perform surveillances. At a minimum fissile material operations are reviewed for NCS on an annual basis (i.e., every 12 months not to exceed 15 months between surveillances). These surveillances are performed by the operating organization. NCS personnel are also present during these surveillances to provide NCS technical support as requested. These surveillances include the inspection of facility modifications, operating procedures, compliance with NCSAs, postings, and waste generation and handling. These surveillances are performed as specified by the NCS procedure.

PORC provides review of the NCS program in accordance with the Technical Safety Requirements.

Independent oversight is provided by internal audits of the NCS program conducted or coordinated by the USEC Safety, Safeguards and Quality Manager. Internal audits of the NCS program shall be conducted in accordance with Section 2.18 of the QAP. The purpose of these audits is to determine the adequacy of the overall NCS program. This includes the adequacy of the NCSEs, NCSAs, internal surveillances, and implementation of the NCS requirements.

NCS walk-throughs of facilities that may contain fissile material operations are performed by NCS personnel to determine the adequacy of implementation of NCS requirements and to verify that conditions have not been altered to adversely affect NCS. These walk-throughs are performed as specified by the NCS procedure on walk-throughs. For example, a walk-through inspection can be performed in response to trend data, at the request of the operations personnel, or due to concerns raised by employees or the NCS staff. As a minimum, these walk-throughs are completed for applicable areas biennially.

The results of these surveillances, audits, and walk-throughs are documented and reported to appropriate managers. Identified deficiencies are documented and corrected according to the problem reporting system described in Section 6.9 and the QAP Section 2.18.

NCS deficiencies are recorded and the data trended to monitor and prevent future violations. Deficiencies are grouped into categories: building, organization/group, mass violation, volume violation, geometry violations, spacing violation, and unauthorized activities. Corrective actions are taken for adverse trends in accordance with the Quality Assurance Program.

5.2.3 Technical Aspects

5.2.3.1 Application of Parameters

Moderation

Water and oil are considered to be the most efficient moderators commonly found on the plant site. When moderation is not controlled, either optimum moderation or worst credible moderation is assumed as the normal case when performing analyses. When moderation is controlled, credible abnormal process upset conditions shall determine the worst case moderated conditions. For example, it has been determined that the worst case moderation under process upset conditions for the oil in the Stokes-Pennwalt Pumps is an H/U ratio of 46.8. This value is based on the amount of uranium the oil can contain and still provide lubrication adequate for pump operation. The addition of more uranium will result in pump failure. Thus, the introduction of uranium into the pump oil is self-limiting.

Moderation control is applied to enrichment cascade equipment and product cylinders. Uranium enriched to 6 wt % or less, ^{235}U is considered to be incapable of supporting a nuclear chain reaction without the presence of moderation. The basis for this statement is provided in a NCSE.

The enrichment cascade is a closed system designed to process gaseous UF_6. This closed system prevents the introduction of moderation due to wet air inleakage. Also because UF_6 reacts chemically with moisture (a moderator) to produce solid uranium-bearing compounds which impedes the proper operation of the cascade, the entire enrichment cascade is designed to minimize introduction of moisture. This includes the use of R-114 for coolant rather than water.

Moderation control is the primary NCS control for product cylinders and is based upon the ability of the gaseous diffusion plants to produce high purity UF_6 (greater than or equal to 99.5%). Assuming the remaining 0.5% impurity was composed entirely of HF, it would not provide sufficient moderation (i.e., atomic ration greater than 0.088 H/U) of the neutrons to sustain a nuclear chain reaction. At the operating temperature and pressure ranges of the Product Withdrawal system hydrogen fluoride (HF) will not condense. This ensures the H/U ratio will remain below 0.088 since only a small, safe amount is dissolved in liquid UF_6.

The pressure in the product withdrawal system at PGDP is determined by the discharge pressure of the UF_6 product withdrawal (Normetex) pumps. The C-310 Normetex pumps are equipped with a high discharge pressure system that will actuate the pump shutdown circuit at or below a pressure of 42 psia. Since the pump will trip at or below a pressure of 42 psia, the HF cannot condense because it would have to be greater than 50 psia to do so. This ensures moderation control and an atomic ratio below 0.088 in the product withdrawal system.

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2.3.2 SAFETY LIMITS

2.3.2.1 TEXT DELETED

2.3.2.2 UF_6 CONDENSER COOLANT PRESSURE

SL 2.3.2.2: C-310: UF_6 condenser R-114 coolant pressure shall not exceed 220 psig.
C-315: UF_6 condenser R-114 coolant pressure shall not exceed 440 psig.

APPLICABILITY: Modes: All

BASIS:

The UF_6 condensers in C-310 and C-315 withdrawal areas are designed and manufactured under ASME code regulations with a MAWP of 200 and 400 psig respectively [SAR Sections 3.4.3, 3.5.4, 4.3.3.1.2, and 4.3.4.1.2]. These pressure vessels were originally hydrostatically tested at 150 percent of the MAWP and are tested by nondestructive examination every five years to ensure their wall thicknesses meet or exceed the minimum wall thicknesses as specified by code. The safety limits are ultimately based on preserving the structural integrity of the UF_6 condensers. The ASME code requires that the pressure transient during relief from this type of vessel not exceed 110% of MAWP. Thus, the safety limit is established at 220 psig and 440 psig for the C-310 and C-315 UF_6 condenser R-114 systems, respectively (110% of MAWP).

SECTION 2.3 SPECIFIC TSRs FOR PRODUCT AND TAILS WITHDRAWAL FACILITIES

2.3.3 LIMITING CONTROL SETTINGS, LIMITING CONDITIONS FOR OPERATION, SURVEILLANCES

2.3.3.1 TEXT DELETED

SECTION 2.3 SPECIFIC TSRs FOR PRODUCT AND TAILS WITHDRAWAL FACILITIES

2.3.3 LIMITING CONTROL SETTINGS, LIMITING CONDITIONS FOR OPERATION, SURVEILLANCES